Cabling Standards

For the State of Tennessee

State of Tennessee

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STRUCTURED CABLING
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A. Structured Cabling Initiative and Overview

The State of Tennessee Telecommunications Department has adopted a fixed set of cabling infrastructure standards to which all communications (voice, data, & video on copper cables, fiber optics, coaxial cables and wireless) installations shall adhere. The purpose of this document is to describe these cabling infrastructure standards. These guidelines shall be used by analysts, system planners, space planners, designers, and architects when approaching state telecommunications wiring planning. When closely adhered to these cabling standards will assure the installation meets industry standards and reduce costs in troubleshooting, moves, adds and changes.

The treatment of telecommunications cabling infrastructure, as a long-term investment is essential. Telecommunications cabling infrastructure must be planned for and funded with the same level of importance and over similar time horizons as all other utilities. An important point to consider at the onset of a cabling venture is that it is less expensive in the long run to over-estimate communications needs at the beginning than it is to add capacity after the fact.

The initial cost of a structured cabling venture may seem expensive. But, it is necessary to consider near-term and future growth when considering this expense. Structured plans become more cost effective over time, because it is easy and relatively inexpensive to move and add Work Areas in a structured plan.

Today's approach towards creating a cabling infrastructure provides the flexibility to support the higher speed and greater bandwidth communications that tomorrow's networks will require. A structure that allows for proper maintenance and record keeping for the infrastructure as additions, moves, and network reconfigurations is necessary as well.

There are two basic elements to this approach. The first is recognition of communications cabling as another designed utility in the building infrastructure. Second, the use of a modular design concept as exemplified in this document.

In today's high-speed information society, it is no longer practical or prudent to view the cabling as an adjunct to the equipment. These old unstructured designs will be inadequate to support electronic equipment and high-speed communications for growth or troubleshooting.

The computer and communications equipment used in a building today will be replaced several times over the potential life cycle of a well designed, structured cabling system installation. Today's networks and equipment will be supplanted by more sophisticated and demanding technologies. Users will require a means to start with modest installations that can accommodate future expansion into building and campus-wide networks

Therefore, flexibility in connectivity is essential to providing both current and future adequate service to our customers. Because of the wide variation in the assignment and the use of office space, a well-defined, fixed set of requirements is necessary to provide this flexibility. Work Area cabling must be capable of supporting a wide variety of voice/data configurations.

The Open Systems Interconnection (OSI) Reference Model is a seven-layer communications processing model used in all communications today. Layer 1 of the OSI model is designated the physical layer. The physical layer is where all the connectivity occurs and the media that transports the signals from one user to another. This physical layer adequately and correctly installed is very critical to the entire telecommunications systems performance.

Copper, fiber and coax form part of the physical infrastructure that is the transport media for transmitting information throughout an organization, connecting a variety of devices such as telephones, personal computers, terminals, modems, facsimile machines, and videoconferencing equipment. The cabling plan should address and adhere to building codes (both national and local), security (both closet entrance and surveillance), disaster recovery planning, and aesthetic concerns. In situations involving wireless applications the other wireless applications in the building plus physical structure have to be considered. A well designed structured cabling infrastructure will account for as much as possible any new emerging and evolving network technologies.

Cable systems management and maintenance of cable records has also emerged as a major cost consideration. A well-designed structured cabling system will not remain that way for very long without a good cable management system. Moves, Additions and Changes (MAC) costs will increase drastically in the absence of a cabling management system.

We are no longer in a world where telecommunications abilities are viewed as a luxury; they are now a necessity to conduct everyday business. The industry now views telecommunications “structured cabling” as the “Fourth Utility” along with Plumbing, Electrical, and HVAC. Structured cabling has now evolved into a basic element of a facility’s infrastructure.

It is essential that Telecommunications Planners and designers be included from the inception, early planning, design, and implementation phases of every Diagram for a Structured Cabling System

A key element in this approach is to plan projects in conjunction with capital projects, property management, other agencies, suppliers, and vendors, emphasizing the importance of looking to the future in planning telecommunications

To insure the integrity and quality of the state’s cabling infrastructure, all cabling placed by the State shall be installed to conform to ANSI/TIA/EIA, BICSI TDMM (Telecommunications Distribution Methods Manual) Standards (in each case the most recent revision) plus any addendums to the State of Tennessee Voice and Data Cabling Infrastructure Standards. In addition to the standards, the documents listed at the end of this section should be referenced in the event any discrepancies or confusion occurs.

B. Design Considerations

1) Standards & Federally Mandated Codes

Successfully designed and implemented cabling systems are based on codes and standards set by the federal government and organizations (respectfully) such as the International Standards Organization (ISO), the Electronics Industries Association (EIA), the Telecommunications Industries Association (TIA), the American National Standards Institute (ANSI), Building Industry Consulting Services International (BICSI), the Institute of Electrical and Electronics Engineers (IEEE), the Federal Communications Commission (FCC) and others. The first wiring standard developed, the TIA/EIA-568, was approved in July 1991. In the fall of 2004 a new revision of the CSI (Constructors Specifications Institute) Master Format, the format by which the approval process of a building design is created, will include Communications as a designated level of the design process. This division of the Master Format is what the telecommunication engineers will use to input the communications layer into the architectural design. In regards to the NEC, which is adopted by most local municipalities as the legal electrical code in their jurisdiction, the local authorities (Fire Marshall and /or building commissioner) have the ability to add more stringent requirements that must be adhered to for the for Fire Marshall to approve and to be able to obtain a building permit. With respect to the other organizations always reference the latest revision of any publication of standards. Here is a list of some of the more applicable codes and standards utilized in a complete design of a structured cabling telecommunications infrastructure.

a) ANSI/TIA/EIA-568-B.1 - Commercial Building Telecommunications Cabling Standards. Part 1

b) ANSI/TIA/EIA-568-B.2 - Commercial Building Telecommunications Cabling Standards. Part 2
c) ANSI/TIA/EIA-568-B.3 – Optical Fiber Cabling Components Standards. TIA-455 – Fiber Optics Test Procedures
d) ANSI/TIA/EIA-569-B - Commercial Building Standards for Telecommunications Pathways and Spaces
e) ANSI/TIA/EIA-854 – Full Duplex Specification for 1000Base-TX
f) ANSI-J-STD-607 - Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications. Also IEEE 1100 – Recommended Practices for powering and grounding sensitive electronic equipment
g) ANSI/TIA/EIA-758 – Customer Owned Outside Plant Telecommunications Cabling Standards.
h) ISO/IEC 11801 – International Organization for Standardization / International electro technical Commission
i) IEEE 802.11 – Wireless LAN's
j) IEEE 802.16 – Broadband Wireless Metropolitan Area Networks
k) Americans with Disabilities Act (ADA) Title IV, Appendix C: Telephone accessibility in public areas.
l) Building Industries Consulting Services International (BICSI) Telephone Distribution Methods Manual (TDMM), Latest Revision.
m) Insulated Cable Engineers Association (ICEA)
n) For Abandoned Communications Cable reference NEC 645.5 (D) (6), NEC 800.2, and 800.53.National Electrical Manufacturers Association (NEMA).
o) American Society for Testing Materials (ASTM).
p) National Electric Code (NEC®).
q) Institute of Electrical and Electronic Engineers (IEEE).
r) Underwriters Laboratories (UL). (UL 444 & UL 13).
s) SYSTIMAX/COMMSCOPE® Structured Cabling Systems, Performance Specifications, latest revision.

2) Communications Rooms/Closets

This communication room will have many names, as discussed later in this section, but each will serve the same main purpose, connectivity. This connectivity creates the network between the buildings internal users and connectivity to the external users if allowed. The Communications closets must be well ventilated, environmentally controlled on a 24 hours per day, 7 days per week basis, maintain a positive pressure with a minimum of one air change per hour, and not present a hostile environment to computer or telephone equipment. Heat dissipation from the telecommunications equipment will vary from application to application and will be provided during the project design so that the HVAC to the room will be sized adequately. Walls for this room should extend from the floor to the deck (floor above) and not be open to a plenum ceiling. All penetrations in this wall for cable entry must be fire stopped and if they are mechanical penetrations they shall be fire rated. Dropped ceilings or permanent ceilings should not be installed in these rooms. Lighting should be installed at a height of 8' 6" and designed to provide a minimum of 50 foot-candles measured at 3 feet above the finished floor. At least 2 walls should be lined with 8 feet tall ¾ inch, AC plywood. Plywood should be fire retardant or painted with a fire retardant light gray or white (NOT BLACK) paint. If painted the plywood shall be painted on the front, rear and edges. Duplex electrical outlets should be installed at the bottom of the plywood at 6' intervals with no more than two (2) duplex outlets per 20 AMP dedicated non-switched circuit. This room should also have duplex dedicated non-switched circuits that are 208 volts, utilizing a 30-amp breaker. If emergency or back-up power is available in the building these circuits will need to be connected to that service. A multi-point ground, conforming to ANSI J-STD-607 and NEC Article 800 and Article 250, with a minimum 6 AWG wire, must be provided in this space to be used for grounding protection devices and equipment. In the environment where multiple delicate electronic communications devices are mounted then each should terminate their ground on the multiple point ground to alleviate voltage potentials. Doors should be at least 36 inches wide and 80 inches tall, installed to swing out with keys maintained by communications personnel. Floors should be tile or treated concrete (never carpeted) to minimize dust and the potential for static buildup. The room must be secure with access limited to responsible telecommunications personnel. All communication rooms should have locking doors with keys unique to communications. In most applications, particularly a multi-floor building, these rooms should be a minimum of 8' x 10'. Several factors will need to be determined when sizing this room, such as the amount of equipment planned for the room, the size of the area it services and what type of room this will be (MDF, EF, IDF). The NEC considers low voltage as anything less than 600 volts and the code for clearances for low voltage is 36”. This is crucial for space between the cabinet or rack (wall or floor) and the wall. If there is equipment on the wall that protrudes from the wall then the distance starts from the furthest protrusion. People must be able to work on the equipment without interfering with the connectivity. When determining the closet size, close consideration has to be given to how much area the closet provides connectivity for and by what degree that floor area can grow or change. The size of the closet and the clearances between equipment will be affected by other vendor equipment that is often placed in the communications area, such as building automation, life and safety, security, audio, and CATV systems. Boiler rooms, air exchange rooms, janitorial closets, electrical distribution closets, elevator equipment rooms or areas with water heaters, wet sinks, or high potentials of EMI or heat are not acceptable for communications use. It is essential that these spaces be dedicated to telecommunication. The design aspects of the closets, which house telecommunications, are specified in the TIA/EIA 569 Standard. A separate lay out must be designed for each closet for each building along with a wall layout showing the separation of riser termination fields and horizontal termination fields. In the instance where there is no closet provided to house the Telecommunications needs then a lockable cabinet can be utilized. The area where this cabinet is located must meet all the parameters as an actual telecommunications space. The cabinets are shown at the end of this document.

a) <u>MDF / MC / Server Room</u>
The MDF (Main Distribution Frame) is also known as the MC (Main Cross Connect). Voice distribution and data distribution emanates from this point. Administration of the communications system also begins here. The local service provider’s Entrance Facility (EF) should also be located in this room or connect directly to this room via tie cable. An MDF may also serve as an IDF (explained in the next paragraph) if it acts as a termination point for horizontal cabling. In some instances this room will house telecommunications personnel and should be adequately sized for a work area. This is the communications room (server room) that will house the majority of the data switching, routing and back-up storage. Due to the sensitivity of this equipment and the large number of devices that can be placed in this room it is best to utilize a raised floor. This maintains better cool and clean airflow for the equipment and easier wire management below the floor.

b) <u>IDF / IC / TC</u>
Intermediate Distribution Frame (IDF) may also be called the IC (Intermediate Cross Connect) or the TC (Telecommunications Closet). The same parameters fall true for this closet as for the MDF. The differences lie in the branch of telecommunications. The riser cables that feed this IDF will come from the MDF. This area will act as a termination and cross connect point for the horizontal cabling to the riser backbone.

c) <u>Entrance Facility (EF)</u>
This closet is the room where the main communications feed enters the building and where the demarcation point is located. It can be an OSP run from the local access provider for voice and/or data or it could be part of a campus OSP design entrance point. The Service Provider’s network interface (RJ-21X blocks or a copper or fiber multiplexer) will be located here. The physical requirements of the network interface are defined in ANSI/TIA/EIA-569. The EF can also be designated as the MDF if that is where the cables enter the building. If the entrance facility and the MDF are not the same room and the OSP cabling has to be run to the MDF before termination, then the cables (copper and/or fiber) have to be transitioned to a cable that is rated for indoor use within 50’ of building entrance or the end of the closed conduit in which they entered the building. The entrance facility conduits shall be at least two (2) 4-inch conduits that run to the property line. The service provider (by law) decides the point at which the OSP cables connect to the local service along the property line.

3) Pathways

Pathways are the routes cabling traverses through, to and within a building. Many different design considerations are utilized in the creation of the pathways. Though cost considerations weigh heavy in the planning stage, feasibility and protection of the cable should dominate the route selection. Within the interior of the building the route will need to remain clear of sources of EMI, humidity, and heat. NEC Article 100 defines pathways.

a) Entrance Facility Conduits

With the sparse array of buildings that are a part of the same company or network topology that need connectivity between them determines that each building needs connection to an outside source Every building must have connection to a WAN or just the outside internet. Entrance Facilities for the local telephone company or access provider must be provisioned. This will consist of a minimum of two (2) 4-inch conduits extending from the MDF or main cross connect (telephone) room to the property line. If the OSP conduits are placed underground and enter the floor of the entrance facility they must be at least 4"above finished floor. Conduit outside the building must be either rigid steel or rigid PVC encased in concrete (where required). The State is responsible for any infrastructure, aerial or underground, to the property line, not including cable.

b) Outside Plant

In a Campus type environment or where there are two or more buildings that will utilize the same network or phone system, there will need to be an outside plant infrastructure designed and placed. There are 3 different ways to connect these buildings for telecommunications, aerial, direct buried (only where specified), and underground conduit. Wireless is another method but discussed in a separate chapter. This system will consist of entry points for each building and the path designated by the designer, which will conform to BICSI's Customer-Owned Outside Plant Design Module.

1) Aerial

In the instances where below ground is not an option or there are existing poles or structures between the two or more buildings that need to be connected then aerial methods can be utilized. Verification of historical buildings or other aesthetic issues need to be considered in designing this route. Penetrations into any building will be coordinated with the building superintendent and will vary depending on the type of exterior wall and the proximity to the necessary point of termination. There are different methods and materials for attaching to different types of exteriors. During the design phase considerations will have to be placed to the possibility of vehicular damage to the area where the poles are or will be placed, risk of close proximity to trees or limbs that could fall on the lines creating outages, amount of utilities at the locations where the poles will need to be placed, distance between the new cable and existing aerial cables (power and communication), the terrain, and the aesthetics after completion. A permit will have to be obtained for crossing any waterways and/or railroads. The controlling regulatory body of the right of way will set the specifications for clearance and crossing. Once the route is designed the contractor shall place strands between support devices to lash the aerial cable too. Slack span runs shall not be utilized between poles. A drip loop shall be placed at the connection to the building. Guy wires placed shall mimic the size of strand wire and will be placed on poles that hold a turn more than 5 degrees. The last pole or connecting structure to the entry point of the building shall be less than 100 feet. Aerial, as far as a new installation should only be considered when there will be or there is no other communications entrance.

2) Underground conduit

In this instance maintenance hole (MH) or conduit system is installed. Manholes and/or hand holes and/or pull boxes are placed as a route connecting each building. No less than two (2) 4-inch conduits should be placed from each point of connection in the OSP system. One of the conduits should be filled with a cellular raceway for fiber such as innerduct or FO-duct. The conduits shall penetrate the wall or floor of each space, per applicable building codes, with a bushing installed on either end to protect the cable. Any open conduits that are not filled at the completion of the install shall be capped with a watertight closure. Although the terrain and local codes will determine the type of conduit installed, generally schedule 40 PVC conduit with a sand or gravel cover is sufficient with a depth of 24" from the top of the pipe to grade. Road crossings or areas subject to heavy loading must be schedule 40 PVC conduits encased in concrete, schedule 80 PVC conduit, or rigid steel conduit. Conduits that run along side of or pass under roads or railways should adhere to all local and federal codes plus BICSI standards. Conduits must have no more than two (2) 90° bends, or a total of 180°, in any single conduit run. All bends must be at least 36" radius bends (sweeping bends, no LB's). If more bends are required, pull boxes, hand holes or manholes (to be determined by the application) must be installed. Conduit length between closets, manholes, hand holes, etc., must not exceed 600', as determined by the application and number of bends in the conduit run. Conduit fill must conform to specifications as listed in the National Electrical Code. For a campus arrangement, conduit should be installed to connect all buildings keeping in mind loop diversity. When the contractor has to enter an existing maintenance hole while performing work for the State of Tennessee (placing new cable, splicing cable or verification of existing) OSHA mandates that a Confined Space Entry Program (1910.268) be in place and certain guidelines strictly adhered to (barricade, gas detection, blower, 3 point harness to a hoist, etc). If a hand hole is placed without a bottom the contractor shall place gravel as a mud barrier at the bottom of the hole.

3) <u>Direct Buried</u>
Due to the lack of protection the Direct Buried solution provides for the medium it is not the preferred method of OSP connectivity for the State of Tennessee. The minimum depth and separation from other utilities applies to direct buried cable the same as underground conduit. The NEC 300.5 mandates the depth for different contiguous regions of the United States, as in every other instance the last code to verify procedures by will be local code. OSHA states that every trench 5 foot or deeper must be shored and the excavated dirt be no closer than 2 foot to the edge of the trench.

c) <u>Horizontal or Work Area Conduits</u>
All conduits installed for workstation cabling must be a minimum of ¾" conduit. Outlet boxes should be a 4" x 4" with a 2" x 4" plaster ring fed by one (1) ¾" conduit. Workstations in a back-to-back configuration may be served with a single ¾" conduit (conduit feed should be sized to meet the conduit fill ratio specified) with two (2) outlet boxes (4" x 4" with a 2" x 4" plaster ring) connected with a conduit nipple of 6" or less. If there are more than 2 outlet boxes connected by one single stub-out then the conduit should be sized accordingly and follow standards of conduit placement. The conduit feed should stub out above the outlet or in the nearest accessible ceiling and when/if it ends before or within the communications closet it should have a plastic grommet placed on the end. If it is placed in a rated wall the stub out shall be placed on the same side of the rated wall as the outlet. Provide riser sleeves and/or conduits, with plastic bushings, for backbone (riser) cabling and sleeves above the dropped ceiling for horizontal (Work Area) cabling as required per the specifications in the State of Tennessee Cabling Infrastructure Standards or designated by a State Cabling Infrastructure Specialist. For horizontal

sleeves that leave the closet, if there is an area with a inaccessible ceiling space then the sleeve should travel to the nearest accessible area. The conduits carrying ISP copper or fiber must have no more than two (2) 90° bends or a total of 180° in any single conduit run or between pull boxes. A single conduit run is defined as that of the distance the conduit travels before it passes the 180 degree standard just stated or 150 foot from pull box to pull box, which ever comes first. A minimum of two (2) 4" sleeves per room/closet should be provided.

4) Backbone/Riser Cabling

The Backbone cabling provides interconnection between telecommunication closets, equipment rooms and entrance facilities. It consists of the backbone cables, intermediate and main cross-connects, mechanical terminations and patch cords or jumpers used for backbone-to-backbone cross-connection. In the situation where the riser cables pass through a communications closet there shall be ladder rack placed for the risers to be attached to for support from the floor sleeve to the deck sleeve. The bend radius should never be less than 10 times the radius of the cable itself. In the instance where an extended distance cannot be avoided the BICSI CO-OSP manual should be referenced to determine a safe pull tension. Tension can damage the ability of the cable to propagate the signal correctly. An excess of tension or speed while being placed within PVC it can meld to the PVC and become immoveable.

a) Copper

Distributions for voice risers or backbones are installed in a star configuration with all cables beginning in the MDF and terminating in the IDF. Riser cables should be of multi-pair design with 24 AWG (American Wire Gauge), polyethylene insulated conductors (PIC) using either filled core shielded buried, air core aerial shielded self supporting or shielded air core riser cabling as required by the application. Cable within a building must conform to specifications in the newest revision of BICSI Telecommunications Distribution Methods Manual, and cables installed in conduit or underground conduit or direct buried or aerial to another building location must conform to BICSI Customer-Owned Outside Plant Manual specifications. The riser copper cable should be sized by the number of phones placed on a floor completely built out times 2 plus a 25% growth factor, for copper OSP connecting buildings the pair count will be figured by square footage. Connection from distribution cabling to station cabling is accomplished with either cross-connect fields or patch cords. Cross-connections for Category 5/5E & Category 6 cabling must be made with patch cords with equal rating. Cross connects should include no more than two hierarchical levels of cross-connects, bridge taps are not allowed, and main and intermediate cross-connect jumper or patch cord lengths should not exceed 20 meters (66 feet). Although UTP should be used for most low voltage applications there may be circumstances where the distance requirements dictate the use many different cabling mediums. Riser cables of other types may also be required to support other applications.

b) Fiber

Technologies continuing to emerge that utilize greater and greater bandwidth such as voice over Internet protocol, streaming video in conference situations along with the normal data traffic accrued in an office environment create the need to lessen the chance of network bottlenecks between communications closets more and more prevalent. All new buildings or major renovations include a Multi-Mode Fiber Optic riser cable for connectivity between the MDF and IDF (network nodes). In campus type situations it will be determined if a mutli-mode or single mode fiber will be needed.

1) Multi-Mode Fiber Optic Cable

Each multi mode fiber placed cable should consist of a minimum of 12, 62.5/125µm, FDDI Grade, fibers. A smaller core size fiber 50/125-micron offers a higher bandwidth capability with a VCSEL but does not couple as much power when using an LED. This decision will be made as long as all connecting hardware will coincide. Larger fiber counts may be required based on the size of the building or campus and the requirements of the customer. Multi Mode fiber optic cable should be terminated with SC or LC Type connectors and distributed in a Light Guide Interconnection Unit (LIU), Light Guide Termination Shelf (LTS), or a rack mounted modular connector panel at the communications closet.

2) Single Mode Fiber Optic Cable

Single mode fiber is similar to multi-mode fiber but has greater performance characteristics. Such as the ability to satisfy high bandwidth needs (10G and greater) unrepeated up to 25 miles. It is even ideal for campus situations where the span is greater than a mile. The electronics to support single mode are more expensive and do not out weigh the price of multi mode for any run shorter than 1 mile. Each cable should be a minimum of a 12 count, 8.3 /125µm, TIA/EIA Class 4d. Single mode shall use LC type connectors.

5) Horizontal/Work Area Cabling

This is the actual cabling that connects each device to the network from the telecommunications outlet/connector as part of the faceplate in the work area to the communications closet (MDF, IDF, EF, TC etc.) also known as station cable. With this configuration, conforming to the Commercial Building Telecommunications Cabling Standard and the ANSI/TIA/EIA-568B configuration standards, all horizontal cables emanate from the IDF (Any communications closet that has station cable terminated in it can be described as an IDF, but not limited to that). It typically consists of two (2) 4 pair, Blue Category 6 plenum rated, unshielded twisted pair (UTP) cable. Both cables will terminate in an 8 position / 8 conductor Cat 6 rated ivory colored jack or outlet in a 4 port faceplate. Traveling through the designated pathway from the work area the cables will terminate in the nearest communications closet on a Cat 6 rated patch panel following both manufacture warranty of certification procedures and BICSI standards. Connection from the distribution cabling to the station cabling is accomplished with either hardwire cross-connects or patch cords. The two cables will terminate sequentially per workstation on the patch panel, not separating voice from data. A Horizontal Cabling Link is all the components of the cabling subsystem, the outlet, horizontal cable, patch panel and/or connecting block. A Horizontal Cabling Channel encompasses all the elements of the horizontal cabling link plus the equipment cable and the patch cords in the communications closet and the work area. The allowable distance of the channel is 100 meters; the allowable distance that the workstation cords and the closets cords can share is 10 meters.

All work area copper cabling and connectors conform to the following specifications:

a) Pathways

Communications cable pathways are the spaces occupied and the hardware involved in the distribution and support of the structured cabling traveling from the telecommunications outlet to the communications closet or from one communications closet to another. A topology is the type or direction of path the cabling travels along from the workstation outlet to the telecommunications closet. All voice and data horizontal cabling, including fiber and copper distribution cabling from one communications closet to another, is installed in a “Star” topology. By using a star topology method of cabling, administration may be performed from the MDF to each IDF without having to “daisy chain” through other communication closets or telecommunications outlet/connectors. This also provides the ability for renovation, if one closet was to be demolished, and in the event a natural disaster removed partial of the building, other areas could remain online. If there is a system or software/hardware application requiring different connectivity it should be treated as a stand-alone and provided a separate connection to the network either through an outside line or an Ethernet connection patched from an outlet or the patch panel. Some installations require cable tray and/or enclosed wire ways. Wire way installations should conform to all applicable standards and codes. Upon reaching work area cubicles, whether the cable enters the cubicles from the wall or a power poll there will need to be either a whip run from the wall or poll or spiral wrap. This is to protect the cables. On an existing or new construction or renovation there will be multiple low voltage systems placed in the ceiling areas. Other systems are not allowed to share the same support structures as the structured cabling.

b) Patch cords

The cross connectivity provided in the communications closet and outlet area is performed by Patch cords, sometimes called ‘line cords’ or station cords’. They connect the work area outlet to the workstation or other work area equipment. In reference to ANSI/TIA/EIA-568B and ISO/IEC 11801, the combination of these cables cannot exceed 33 foot as long as a consolidation point has not been utilized between the closet and the outlet.

c) Outlets

A typical Telecommunications outlet consists of a quad (four (4) hole) faceplate, configured for up to 4, jacks, or couplers (copper, fiber or coax). The standard configuration of each outlet has two, 4 pair, non-keyed, Category 6 jacks. Optionally, it can be equipped with an, ‘F’ type connector, a fiber optic connector, and/or a video coupler. Each jack is also clearly labeled to distinguish it from other jacks. The type of mounting whether it is surface, furniture, or flush, will be determined by the application and wall type. It all new construction and major renovations there will be a conduit placed in the wall (described in “Work Area Conduits”). In locations where the contractor has placed cabling into a fire rated wall then outlet box shall be required to be rated and where the cabling penetrates the wall above the ceiling will have to be fire proofed.

6) Grounding and Bonding

The National Electrical Code (NEC) Article 800, Article 250, National Fire Protection Association (NFPA) 780, ANSI J-STD 607, and IEEE 1100 all have specifications that are applicable to telecommunications installations and must be adhered to. All equipment racks, wire ways, backbone cables and any other device connecting to the cabling infrastructure that could create transient voltages and potentials must be bonded together, grounded and protected in compliance to each of these. A multi-point ground system shall be attached to, at a minimum, building main panel ground with at least a #6 AWG cable from the main telecommunications grounding bus bar. NFPA 780 also requires that a communications ground must be bonded to the lightning protection system grounding within 12 feet of the base of the building. A grounding bus bar shall be placed in each telecommunications closet. Consideration should be given to placing all the electronically sensitive data equipment on this ground bus bar. This will alleviate the differences in potentials that could exist in the telecommunications closet from having separate grounds. Verification of different component warranties should be checked before this can happen. A single connection at one point and extending through the building is not acceptable. The ground wire size will be determined by the application, but a minimum 6 AWG wire is to be used, as referenced before. Where a multitude of devices are placed on one bus bar then the size of the ground wire that connects that bus bar to the appropriate building or power ground should be sized accordingly.

a) Lightning Protection

The NEC requires any aerial or underground cable that is exposed to the potential of coming in contact with anything carrying over 300 volts to be placed and surge protection blocks after breaching the exterior of a building on both ends. The State of Tennessee requires this for all of those situations of OSP cable entering a building. With the price and the sensitivity of all the electrical components connected to the structured cabling infrastructure the need for protection against exterior system surges is very important. At any given point where a copper cable penetrates the exterior of a building, before it can be connected to any piece of equipment, each pair shall be terminated on a panel designed for lightning protection. This panel can be composed of gas charged shocks or fuses, the first being the more common. If there is a metallic locater in the fiber this too will need to be grounded to keep the potential out of the fiber cabinet.

7) Wireless

The State of Tennessee has begun to adopt more and more wireless applications. Wireless and Microwave systems lend themselves to a wide variety of uses, point-to-point (backbone network), cellular personal communications systems, wireless private branch exchanges, wireless local loop, wireless local area network, and competitive access. There are 6 basic parts to every radio system. A power source, transmitter with a modulator, an amp to be able to transmit, an antenna to transmit and receive, receiver and an amp to boost incoming signal. Factors that determine the design are the allowable available frequencies, terrain and vegetation growth, required system capacity, traffic density and the mobile traffic density. Factors that determine whether or not wireless is a viable option are the number of points to be served, system capacity requirements, reliability requirements, operational requirements, and the costs of the alternative. Point to point wireless is the most common utilization of wireless for State of Tennessee applications, a 2.4 GHz line of sight link between two buildings for connectivity.
In a WLAN (wireless local area network) there are access points installed that do have to be cabled back to the communications closet from the actual antenna but have provide connectivity for mobile use. The current WLAN access point has a usable range of 300 feet but due to the propagation of the signal it can be received as far as 1000 foot away in optimal conditions. The maximum number of users that shall be placed on each access point is 20. In the placement of a wireless system in an existing building a complete survey has to take place to determine all of the wireless applications that are currently within the building for the purpose of avoiding interference.

8) Other Transport Media

With the number of legacy systems that have to remain in place within or stand alone adjacent to the new structured cabling infrastructure there can be instances where something other than the previous mentioned connectivity solutions is needed. These various cables can be used to distribute a wide range of data systems other than the typical Cat 6 for Ethernet. Some of these special design consideration cabling systems could be for a internal database with specific transfer methods, Token Ring, CATV, CCTV, Paging Systems, Building Automation cabling, nurse call cabling, video, etc. Some of the other cabling types that may be determined necessary by the analyst are Category 3 or 5, Shielded Twisted Pair Cable (2 or 4 pair), Coaxial Cable, mutli-pair conductors with pre-determined connector pin-outs and different AWG size cables within the same sheath. As per state standards each of these cables must remain plenum. Each of these individual types of premise cable they will have corresponding types of termination and installation procedures recommended by the manufacturer. Because of the different signal strengths, power ratings and acceptance/emission of EMI these cables shall be placed in separate support structures along the pathways, sleeves and entry points to closets.

9) Infrastructure Color Coding

Using color-coded termination fields will make cable plant administration easier. The color codes for cable termination fields are:

COLOR	IDENTIFIES
Orange	Demarcation Point (RJ21X / LEC interface)
Green	Network Connections (Network and Auxiliary Equipment)
Purple	Common Eq. (PBX's, LAN's, Multiplexers, switching, data)
White	First Level Backbone (MC to IC or closet)
Gray	Second Level Backbone (IC to closet)
Blue	WorkStation Cable (Horizontal cable)
Brown	Inter-building Backbone (Campus Cable Termination's)

Yellow	Miscellaneous (Auxiliary, alarms, security, etc.)
Red	Reserved for future (or Key Telephone Systems)

10) Disaster Planning

The possibility of a cabling disaster is usually not considered until a disaster occurs. However, because cabling involves an investment in a huge physical apparatus that can fail in any of a thousand different ways, every cabling project should include a preliminary analysis to determine whether the agency/users critical mission and its need for immediate redundant backup or if the application of the state WAN/LAN Disaster Recovery Plan is applicable.

In line with this Disaster Recovery plan**,** every organization should have a written disaster plan that addresses topics including alternate sites, personnel required to handle the disaster and cleanup, information records, and a detailed plan for recovery. The plan should be evaluated before the cabling is completed to ensure that the organization will not depend on any single critical element and that the recovery plan will provide adequate short-term capabilities.

C. Implementation Guidelines

1) Contractor Qualifications

Every 3 to 5 years the State of Tennessee creates and places on the open market an RFP. From this bid a contractor is awarded the contract for the specified amount of time for the entire state's cabling installation. This contractor chosen must be certified by the manufacturer of the products, adhere to the engineering, installation and testing procedures and utilize the authorized manufactured components. The contractor shall be experienced in all aspects of this work and shall be required to demonstrate direct experience on recent systems of similar type and size. At the close of each project the contractor will be responsible for the delivery of test results of all cabling involved and as-builds, in the state requested format. The contractor is responsible for the pulling of the low voltage permit where applicable and maintaining the state requirements for whatever contractor electrical license's mandatory for that area.

2) Abandoned Cable Removal

The most recent NEC directive states that it is mandatory to remove all "Abandoned Cable". NEC defines abandoned cable as "installed communications cable that is not terminated at both ends at a connector or other equipment and is not identified for future use with a tag". There will be two separate scenarios in which this process will be necessary.

a) New Construction
When there is an existing building or space that housed telecommunications equipment and the area is being completely renovated, all of the old cabling will need to be removed. In most instances this will be taken care of during the demolition phase of the current space. Note: If there are other areas in the building or space that state agencies occupy then there is a need to verify that no backbone cabling travels through the area to be demolished. This work will need to be closely scheduled with the general contractors removal of other systems within the space so there is no confusion of building systems wire with communications cable.

b) Renovation
In the situation of renovation and the existing system has to remain active until the new cabling infrastructure is complete, it will need to be marked as such. This will happen by tagging the old and new cables appropriately as the cables are installed. If

there is an area in a new build-out that there is a need for extra cables to be placed in the ceiling area for a later install they shall be labeled as so, per NEC 645.5 and 800.2.

3) Labeling Scheme

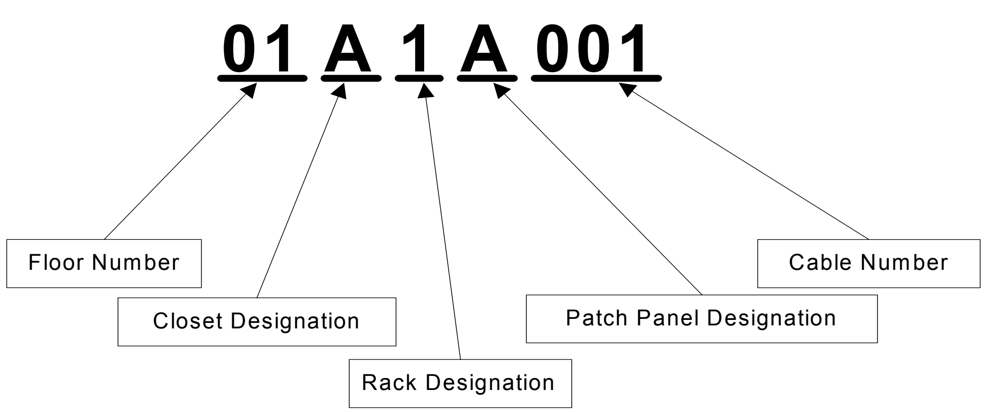
In a common cabling infrastructure work environment you could have multiple cables that look exactly alike placed to each employee. All of this cabling placed to a single closet, terminating in the same rack or into identical racks beside each other or in some cases multiple closets per floor. For the ability to even begin to start patching or moving users or troubleshooting there has to be in place a defined labeling scheme. Because of the different configurations of voice/data applications per outlet there also has to be a common symbol per outlet type. BICSI symbols from the TDMM's will be used as the state standard. A labeling scheme will also prevent the inadvertent placement of different types of cabling in the same support structures. At each point a riser or entrance cable (fiber or copper) enters or leaves a communications closet or room it should be labeled as exactly what it is and where it is being terminated or spliced on the other end. Any homerun conduits leaving the closet should be labeled as to where they end. Before any new cables are placed the contractor shall look at the last number in sequence and label new cables from that point.

a) Closet
Closet doors will be labeled with the proper designation, i.e.,
FF = Floor Number 00 – 99, i.e., or applicable designation.
C = Closet Number A – Z

b) Rack
Racks will be identified in each Telecommunications Closet using a one digit alphanumeric symbol. Racks will be numbered sequentially, 1 thru 9, depending upon the number of racks.
If racks are not used, i.e., wall mounted shelves, the same scheme applies. The shelves will be numbered as if it were a rack.

c) Patch Panel or 110 Block
Patch Panels will be identified in each Telecommunications Closet using an alpha character, A thru Z, depending upon physical location on patch panel, numbered from top to bottom.

d) Workstation outlet
All cables will be labeled with a nine digit alphanumeric symbol as follows. One label will be associated with each jack or outlet, therefore one label will be associated with each jack or outlet; a dual faceplate with 2 jacks will have 2 labels; a quad faceplate with 4 jacks will have 4 labels; etc. Spaces not required.



4) Installation

The State of Tennessee has utilized AVAYA cabling since the conception of an effort to install a structured cabling solution. For continuity and compatibility the new contract has been written so that the contractor shall only place end-to-end solution of what is now Systimax/CommScope plenum cabling and connectivity. Some end users and designers believe that small installations, especially those using unshielded twisted pair cables, are simple and easy to install and often will install one or more cables without proper qualifications. This often results in incorrect or poor installations. Cable installation requires attention to minute details and care in handling the medium. All components must match the specified category 6 UTP end-to-end solution criteria, such as the connectors, patch panels, patch cords, support structures, etc. to attain the Giga-speed transmission. Category 6 UTP installers can untwist no more of the sheath than it takes to keep it out of the cap. The State of Tennessee specifies that all cable installations be adequately tested, covered in "Acceptance Testing". There shall be no splices placed in horizontal balanced twisted pair cable. With the specifications of Cat 6 cable there should not be a service loop placed at the outlet location. In the communications closet the distance the cabling travels before it mounts into the rack and patch panels is part of the loop, as shown in the drawing (entering comm. room away from termination side of rack).

a) Physical Factors affecting installation

There are many physical factors to consider about structured cabling, including weight, diameter, bending radius, pull force, and termination all of which can cause degradation of the signal being transmitted through the cable. Cables have pull load and geometric deformation limits. If pulled too hard, a copper medium can stretch and destroy the geometry. Kinking, bending, and crushing can also damage cables by either breaking the medium or causing geometric deformations that can degrade performance significantly.

1) Cable Weight

Cable weights become important in suspended ceiling loads due to the number of cables that are being supported. Cabling shall never hang from other equipments support. All cabling installed shall have its own Cat6 rated J-hooks, cable tray, etc. The number of cables placed in the supporting device should follow manufacture directions. Cables should be supported every 5 to 10 feet, depending on the number of cables in the bundle, to prevent sags and eventual cable failure. Bridle rings and tie-wraps to ceiling grid hangers or conduit are not acceptable. Cables should never support connected devices (e.g., amplifiers, splitters, and transceivers). These devices must be individually attached to a wall, ceiling, or other sturdy structure.

2) Bending Radius

Minimum bending radius becomes extremely important when installing cables. Fiber-optic cable, in particular, is extremely sensitive to bend radius, and kinks in fiber-optic cable can render the cable useless. All cables, regardless of type, must be installed with as few bends as possible. If manufacturers specifications are not available, a general 'rule of thumb' for copper cable is a bend radius of not less than 10 times the outside diameter of the cable, and for fiber optic cable, 15 times the outside diameter is usually sufficient. During installation the cables maximum bend radius will be less than it would be during actual working conditions.

3) Pull Force

Pull force determines how hard the cable can be pulled. Connectors must never be used to pull cables, since the connectors often break. A 2 to 4 strand count fiber-optic cables have a maximum pull force of 50lbf, while 4-pair UTP cable has a maximum pull force of 25 lbf. Manufacturer specifications should be followed according to the number of copper or fiber strands there are in the cable that is being placed. The 25 lbf for 4-pair UTP does not work as a multiple per number of cables that are in the bundle being placed.

4) Termination

This applies to both ends of all cables. Terminations include the 110 punch down block, patch panel, LIU (shelf or wall mount), lightning protection blocks in the closet, the registered jacks, coaxial connectors or fiber connectors in the faceplate at the work area, the ends of the patch cords in both the work area and the closet, and any other termination point or end to a cable run. Unused cable ends must be properly terminated to reduce accidental shorts and electrical problems. According to NEC requirements an abandoned cable is one that is not terminated at both ends, so if any cables fit this guideline they will have to be removed or tagged for future use. Termination equipment (connectors, patch panels, etc.) must meet the specifications of the type and grade of cable used in the installation plus be of the same manufacture for an end-to-end solution. Cable termination units are color-coded to reduce installation errors. Wall plates are designed to hold multiple (one to eight) voice and data connectors. All connectors in a cabling installation must be clearly labeled.

5) Conduit Fill ratio

The conduit fill ratio is comprised of both cable degradation issues and fire codes. The maximum number of cables that can be in a conduit that penetrates a rated wall or the traverses from one level of a building to another level is shown in the table below. This is standardized due to the expansion rate of fire caulk or putty in a fire situation.

Number of Cables	Maximum Percent Conduit Fill
1	53
2	31
3 or more	40

The maximum number of cables allowed in a conduit run is limited to the number of 90-degree bends and there must be less than 150 foot between pull boxes. If an excess number of cables are placed within a conduit then the bend radius and pull tension degrade the ability of the cable to perform.

6) Fire Wall Penetrations

Any wall that is considered rated must meet the fill ratio requirements and have adequate fire caulk and steel wool in place or it will not pass the Fire Marshall inspection. When a contractor penetrates an existing sleeve that has been caulked for fire propagation prevention it is his responsibility to return or to make sure the rating of the wall has not been degraded because of the sleeve.

b) Wire Management

Cabling installers must be certain that every cable has labels conforming to TIA/EIA standards. The few minutes spent planning and marking additions or moves can save many hours of sorting out the cabling scheme later.

5) Acceptance Testing

To comply with the high expectations and the tender nature of the cabling placed we need to verify the manufacture's specifications and contractor's installation practices through acceptance testing. This same test equipment can be utilized for troubleshooting of the cable.

a) Test Equipment

All test equipment will need to be calibrated at the manufacture's required time frames and records kept to show results of calibration. Testing of all cabling shall be performed prior to system cutover. All fiber launch cords or copper patch cords that will be used for testing shall be the ones used for calibration and to establish reference points.

1) Manufacturers Warranty
The Contractor, backed by the manufacturer, shall provide a minimum (20) year Extended Product Warranty and System Assurance Warranty for this Systimax/CommScope cabling system. This warranty shall include the end-to-end channel.

2) OTDR
An Optical Time Domain Reflectometer (OTDR) identifies irregularities, breaks, splices, length and other discontinuities in fiber-optic cable. By reviewing the events of the fiber trace you can approximate where the actual irregularity is in the fiber. The basic tools for troubleshooting fiber-optic cable include an optical power meter, light source, and inspection microscope along with the OTDR.

3) Power Meter
The Power meter will show the total loss (in dB) for the entire length of the fiber in both directions by measuring end-to-end attenuation, splice and connector loss, light intensity, and continuity. Power meter results are obtained by testing each fiber in both directions at each wavelength and the end result is the correlating wavelength sum divided by 2.

4) Copper multi-tester
This device shall be programmed, calibrated and certified from the manufacturer to test the CAT6 parameters defined by ANSI/TIA/EIA 854.

b) Fiber
All fiber testing shall be performed on all fibers in the completed end-to-end system per the parameters of TIA-455 series. Testing will be done with the fore mentioned OTDR and Power Meter. The system loss measurements will be recorded at 850 and 1300 nanometers for Multi-Mode fibers and 1310 and 1550 for Single Mode fibers.

1) Loss Budget
To calculate the maximum allowable loss a single connector-to-connector fiber link shall have you take the (maximum insertion loss per km –different per fiber type) times (# of km's in fiber link) + (.5dB) times (number of connectors) = maximum allowable loss. This number will be compared to the power meter results for determination of allowable loss. This procedure should only occur after the Power meters have been referenced to each other with the launch cords that will be used for testing.

Multi Mode (both 62.5 & 50 micron)	850 nm	3.5 dB/km
	1300 nm	1.5 dB/km
Single Mode (8.3 micron)	1310 nm & 1550 nm	1.0 dB/km

c) Copper
100 % of all copper riser cables will be tested for breaks, open or crossed pairs. Category 6 cables have a bandwidth of 200MHz and are designed to support the more robust bandwidth applications so they all have top be tested for conformance per the specific parameters that denote their transmission specifications found in ANSI/TIA/EIA 568B Category 6. These basic link parameters are Insertion Loss, Near End Cross Talk (NEXT), Power Sum Equal Length Far End Cross Talk (PSELFEXT), Return Loss, Length, Characteristic Impedance, Attenuation, and Wire map. All other category wire also has to be tested at it's own specific parameters

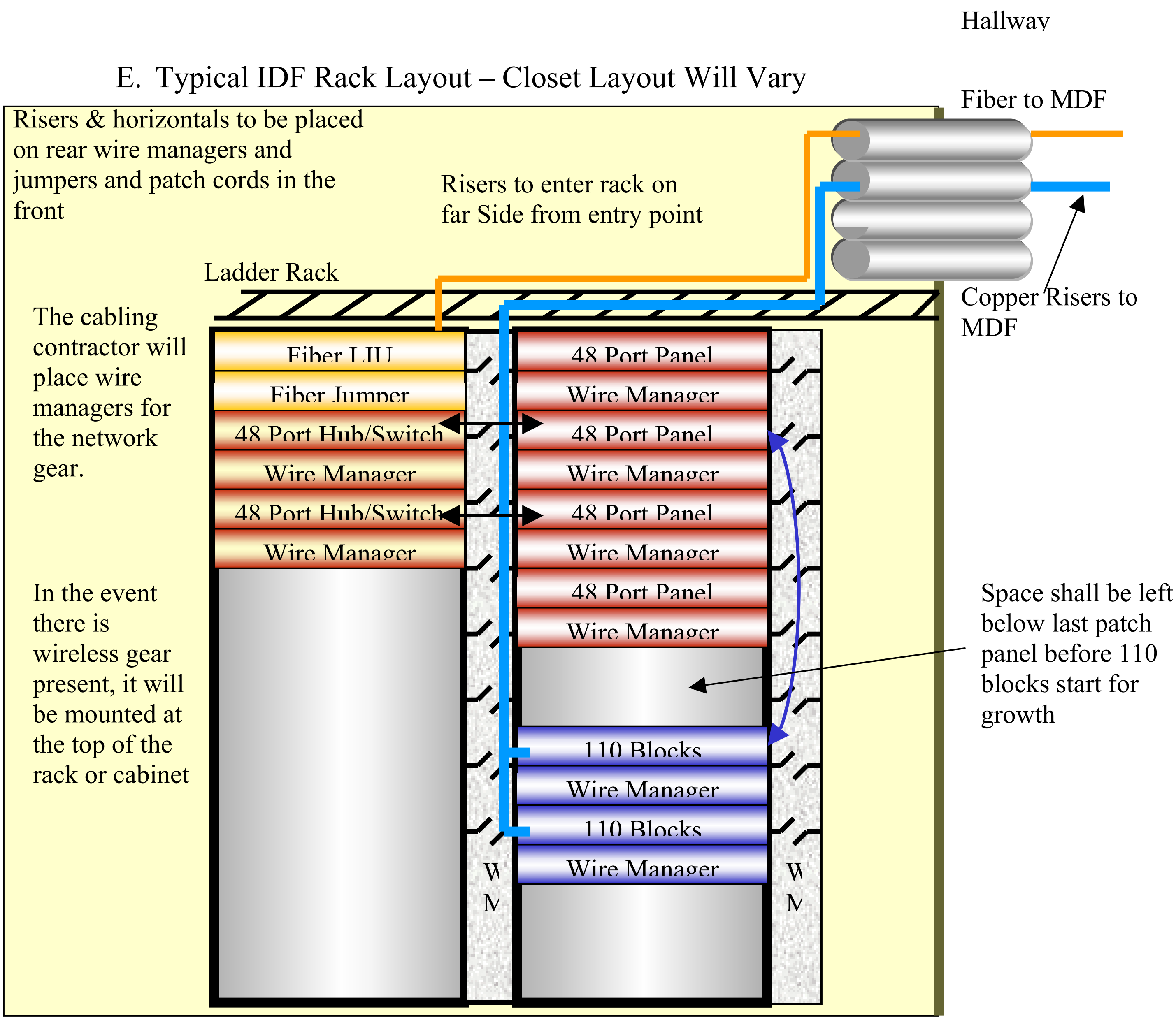
d) Pre-Installation Testing
All Light Guide cable will be tested prior to the installation of the cable. The Contractor assumes all liability for the replacement of the cable should it be found defective at a later date.

D. GLOSSARY

ANSI	American National Standards Institute
AWG	American Wire Gauge
BICSI	Building Industry Consulting Service International
CATV	Community Antenna Television
CCIR	Consultative Committee on International Radio
CCTV	Closed Circuit Television
CO-OSPDM	BICSI Customer-Owned Outside Plant Design Manual
DEMARC	Local Exchange Carrier Demarcation Point
EF	Entrance Facility
EIA	Electronic Industries Association
EMI	Electromagnetic Interference
FCC	Federal Communications Commission
FDDI	Fiber Distributed Data Interface
IDF	Intermediate Distribution Frame (IC)
IEEE	Institute of Electrical and Electronics Engineers
ISDN	Integrated Services Digital Network
ISO	International Standards Organization
LAN	Local Area Network
LEC	Local Exchange Carrier (Telephone Company)
MDF	Main Distribution Frame (MC)
MAU	Media Access Unit or Multi-Station Access Unit
NEC	National Electrical Code
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
OIR	Office for Information Resources (State of Tennessee)
OSHA	Occupational Safety and Health Act
OTDR	Optical Time Domain Reflectometer
PBX	Private Branch Exchange
PIC	Plastic Insulated Cable
POTS	Plain Old Telephone Service
RFI	Radio Frequency Interference
REA	Rural Electrification Administration
SAN	Storage Area Network
ScTP	Shielded Twisted Pair (foiled twisted pair – FTP)
TDMM	Telecommunications Distribution Methods Manual
TIA	Telecommunication Industries Association
TP-PMD	Twisted Pair - Physical Medium Dependent
TSB	Technical Service Bulletin

UL	Underwriters Laboratories
UTP	Unshielded Twisted Pair
WAN	Wide Area Network

E. Typical IDF Rack Layout – Closet Layout Will Vary



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SMALL INSTALLATIONS – 1TO 24

A wall cabinet with a "T-lock" will be installed in a place selected by the state Cabling Group. Cabinet will be 42" x 24.2" x 14" with capacity for 4 shelves.

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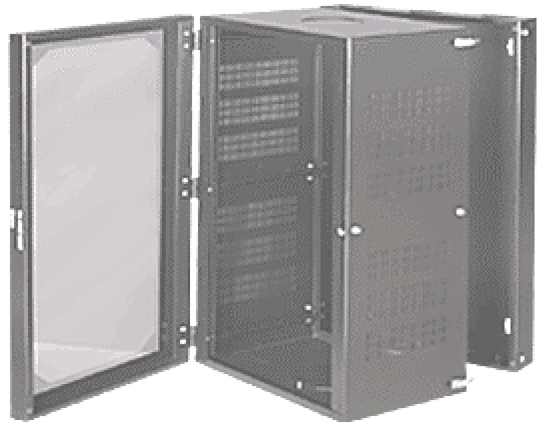
MEDIUM INSTALLATIONS- 25 TO 48

A wall cabinet with a "T-lock" will be installed in a place selected by the state Cabling Group. Cabinet will be 24" x 22" x 26" with capacity for 12 shelves.



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LARGER INSTALLATIONS – 49 +

A floor cabinet with a "T-lock" will be installed in a place selected by the state Cabling Group. Cabinet will be 84" x 29" x 36" with capacity for 46 shelves.

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WIRING CLOSET

Floor racks will be installed to hold all equipment. These racks will be 7' x 19". This floor rack can only be used in a locked Communications Room where access is limited to state personnel.

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Access to all cabinets will be controlled through the "T-Locking" system. All cabinets will have the same key so access by multiple state departments technicians and vendors is possible. "T's" will be left with non-consolidated agency locations but not consolidated locations. Updated "T" distribution lists will be maintained by vendor and supplied to the Cable Group to keep security tight. The universal "T" locking system will allow for manufacturer substitutions/upgrades and changes in the states requirements.